

542-411, Final

**Mars Global Surveyor**

# **Delta II 7925A Target Specification**

FINAL

February 1996



**Jet Propulsion Laboratory**  
California Institute of Technology

JPL D-12728

## Mars Global Surveyor

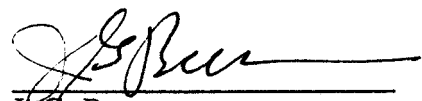
# Delta II 7925A Target Specification

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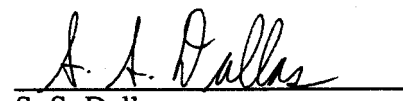
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February 1996



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The spacecraft mass properties for the various launch configurations given in this document were provided by Bill Mateer.

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## DOCUMENT CHANGE LOG

Date	Document State	Comments/Affected Pages
6/95	Preliminary	
2/96	Final	All

## ABBREVIATIONS AND ACRONYMS

Btu	-	British thermal unit
$C_3$	-	Injection energy per unit mass ( $V^2$ ), $\text{km}^2/\text{s}^2$
CCAS	-	Cape Canaveral Air Station
cm	-	centimeter
deg	-	Degree
DLA	-	Declination of Launch (Departure) Asymptote, deg
DSN	-	Deep Space Network
DSS	-	Deep Space Station
DTO	-	Detailed Test Objectives
EME2000	-	Earth Mean Equator and Equinox of Epoch J2000
ET	-	Ephemeris Time (Assumed: $\text{ET} = \text{UTC} + 62.183 \text{ s}$ )
fps	-	feet / second
ft	-	Foot
GM	-	Gravitational Constant * Mass of Earth or Moon
GMT	-	Greenwich Mean Time (Assumed to be equivalent to UTC)
GSFC	-	Goddard Space Flight Center
h	-	Hour
$J_2$	-	Second Zonal Harmonic Coefficient of the Gravitational Potential of Earth
$J_3$	-	Third Zonal Harmonic Coefficient of the Gravitational Potential of Earth
$J_4$	-	Fourth Zonal Harmonic Coefficient of the Gravitational Potential of Earth
JPL	-	Jet Propulsion Laboratory
kg	-	Kilogram
km	-	Kilometer
KSC	-	Kennedy Space Center
lb	-	Pound (force)
m	-	Meter
MDA	-	McDonnell Douglas Aerospace
MELVS	-	Medium Expendable Launch Vehicle Services
MET	-	Mission Elapsed Time
MGS	-	Mars Global Surveyor
nmi	-	Nautical Mile
N	-	Newton
NASA	-	National Aeronautics and Space Administration
NCS	-	Nutation Control SystemF

## **ABBREVIATIONS AND ACRONYMS**

(continued)

OLS	-	Orbital Launch Services
PCS	-	Probability of Command Shutdown
PD	-	Project Document
PMA	-	Preliminary Mission Analysis
PQ	-	Planetary Quarantine
RLA	-	Right Ascension of Launch (Departure) Asymptote, deg
rpm	-	revolutions per minute
s	-	Second
S/C	-	Spacecraft
SECO	-	Delta Second Stage Engine Cutoff
TCM	-	Trajectory Correction Maneuver
TECO	-	Delta Third Stage Engine Cutoff, Third Stage Motor Burnout
USAF	-	United States Air Force
UTC	-	Universal Time, Coordinated
V	-	Hyperbolic Excess Velocity, km/s
W	-	Watt

# **SECTION 1**

## **INTRODUCTION**

### **1.1 PURPOSE**

The Mars Global Surveyor (MGS) mission will deliver a single spacecraft to Mars during the 1996 Mars opportunity. The spacecraft will be launched in November 1996 using a McDonnell Douglas Delta II 7925A from the Cape Canaveral Air Station (CCAS) using Space Launch Complex 17A at the USAF Eastern Space and Missile Center in Florida. The Delta II 7925A launch vehicle is being procured as an option under the Medium Expendable Launch Vehicle Services (MELVS) contract. The MELVS contract is managed by NASA-OLS (Orbital Launch Services) Project at the Goddard Space Flight Center (GSFC).

The main purpose of the Mars Global Surveyor Delta II 7925A Target Specification document is to define the launch period and Earth relative departure conditions that must be achieved by the Delta II 7925A launch vehicle in order to place the MGS spacecraft onto the required interplanetary transfer trajectory. Also defined in the Target Specification document are spacecraft sun avoidance, thermal roll, separation, and collision avoidance attitude requirements placed on the Delta upper stages during powered and coasting flight. In addition, this document identifies the trajectory data products required by the MGS Project from the Delta Program for trajectory verification and operations planning.

### **1.2 SCOPE**

This Target Specification presents target conditions for 32 launch opportunities within the November 1996 Mars Global Surveyor launch opportunity. The launch period spans the 21 days beginning on November 5th and extending through November 25th. From November 5th through November 15th, the MGS Project plans to utilize two discrete launch opportunities per day. From November 16th through November 25th, the MGS Project plans to use one discrete launch opportunity per day. The Earth relative target conditions are specified by expressing the injection energy per unit mass ( $C_3$ ), the declination of the launch asymptote (DLA), and the right ascension of the launch asymptote (RLA).

This document is the Final Target Specification for Mars Global Surveyor and supports the generation of the McDonnell Douglas Detailed Test Objectives (DTO) Report.

### 1.3 RELATIONSHIP TO OTHER DOCUMENTS

The Target Specification is consistent with and responsive to the requirements and objectives of the following project documents.

JPL Document Number	Current Issue Date	Document (Project Document Number)
D-12088	9/95	Mission Plan (PD 542-405, Final)
D-12249	11/30/94	Launch Vehicle Systems Requirements (PD 542-180)
D-12742	6/95	Planetary Protection Plan (PD 542-402)

Portions of the Target Specification are referenced in and form part of the following contractor documents.

Contractor Documents	Current Issue Date	Document
MDC 95H0026	(2/96)	Delta II Mars Global Surveyor (MGS) Mission Specification Mission Requirements and Vehicle Description

## **SECTION 2**

### **DEFINITIONS AND COORDINATE SYSTEMS**

#### **2.1 LAUNCH PERIOD**

The launch period is the set of contiguous launch dates which provide opportunities for injection onto interplanetary transfer trajectories to Mars.

#### **2.2 DAILY LAUNCH OPPORTUNITIES**

The daily launch opportunities are the two intervals of time during a launch day when, for a given launch azimuth, the parking orbit trajectory plane contains the departure asymptote. For a launch vehicle limited to a fixed launch azimuth, each of the two launch opportunities occur instantaneously. These two launch opportunities are often referred to as the long and short parking orbit coast opportunities.

#### **2.3 LAUNCH WINDOW**

The launch window is that interval of time during a launch day for which a Delta II 7925A launch is planned. On a given launch day, the launch windows occur instantaneously and define the time of liftoff. The liftoff time is determined by the declination and right ascension of the launch (departure) asymptote, the latitude and longitude of the launch site, and the launch azimuth.

#### **2.4 LIFTOFF**

Liftoff refers to the time of launch necessary to achieve the desired target sets in Section 4. Liftoff is expressed in Coordinated Universal Time (UTC).

#### **2.5 PARKING ORBIT**

The parking orbit is the circular orbit established by the Delta II 7925A launch vehicle following the first cutoff of the Delta second stage (SECO 1). The parking orbit will have a nominal perigee altitude of 185.2 km (100 nmi) (Reference 1).

#### **2.6 INJECTION**

Injection is defined to occur at burnout of the Delta third stage (TECO). Delta third stage burnout nominally occurs 87.58 seconds after third stage ignition (Reference 1).

#### **2.7 INJECTED MASS**

The injected mass consists of the MGS spacecraft mass (spacecraft bus plus instrument payload and propellants).

#### **2.8 DESPIN**

Despin refers to the deployment of the Delta II 7925A yo-yo system and the nulling of the combined Delta third stage/spacecraft injection burn spin rate. Despin will occur at a fixed time after Delta third stage ignition. Despin nominally occurs 371.0 seconds after third stage ignition (Reference 1).

## 2.9 SEPARATION

Separation refers to the actual separation of the MGS spacecraft from the Delta third stage. Separation will occur at a fixed time after Delta third stage ignition. Separation nominally occurs 376.0 seconds after third stage ignition (Reference 1).

## 2.10 TARGETING INTERFACE POINT

The targeting interface point (TIP) is defined to occur 10 minutes after Delta third stage ignition. The target conditions are specified at the targeting interface point. This point is defined to occur after spacecraft separation from the Delta third stage on all launch days so that all of the propulsive events that could influence the spacecraft's trajectory, attributable to the Delta launch vehicle, will have been completed (Reference 2).

## 2.11 TARGET CONDITIONS

The Earth relative target conditions are specified by expressing the injection energy per unit mass ( $C_3$ ), the declination of the launch asymptote (DLA), and the right ascension of the launch asymptote (RLA) as constants for each day of the launch period. The target conditions represent the conditions of the osculating departure hyperbola at the targeting interface point expressed in an Earth centered, inertial, Earth Mean Equator and Equinox of Epoch J2000 (EME2000) coordinate system.

## 2.12 TARGET SET

A target set is defined to be the three constants ( $C_3$ , DLA, and RLA) which are necessary to define the Earth relative target conditions on a given launch day.

## 2.13 EARTH MEAN EQUATOR AND EQUINOX OF EPOCH J2000 COORDINATE SYSTEM

The Earth Mean Equator and Equinox of Epoch J2000 (EME2000) coordinate system is an inertial coordinate frame with its origin at the center of mass of the Earth. The fundamental reference plane is the mean equatorial plane of the Earth on Julian Date 2451545.0 or January 1.5 (Jan 1, 12h) 2000. (Julian Dates are a continuous count of days since Jan 1, 12 h, 4713 B.C. = Julian Date 0.0.) The +X-axis is defined by a vector along the intersection of the ecliptic plane and the fundamental reference plane in the direction of the Vernal Equinox (first point of Aries). The +Z-axis is defined by a vector along the Earth's rotation vector (Earth's north pole) perpendicular to the mean equator. The +Y-axis completes the right-handed coordinate system (Reference 3).

## 2.14 SPACECRAFT COORDINATE SYSTEM

The origin of the spacecraft coordinate system is in the Delta third stage/spacecraft separation plane. The +Z-axis is perpendicular to the nadir panel and points in the direction of that same panel. The +X-axis is perpendicular to the +Z-axis and extends through the stowed high gain antenna panel. The +Y-axis completes the right-handed coordinate system and extends through the stowed solar array panels. The spacecraft coordinate system is illustrated in Figures 2.1 and 2.2.

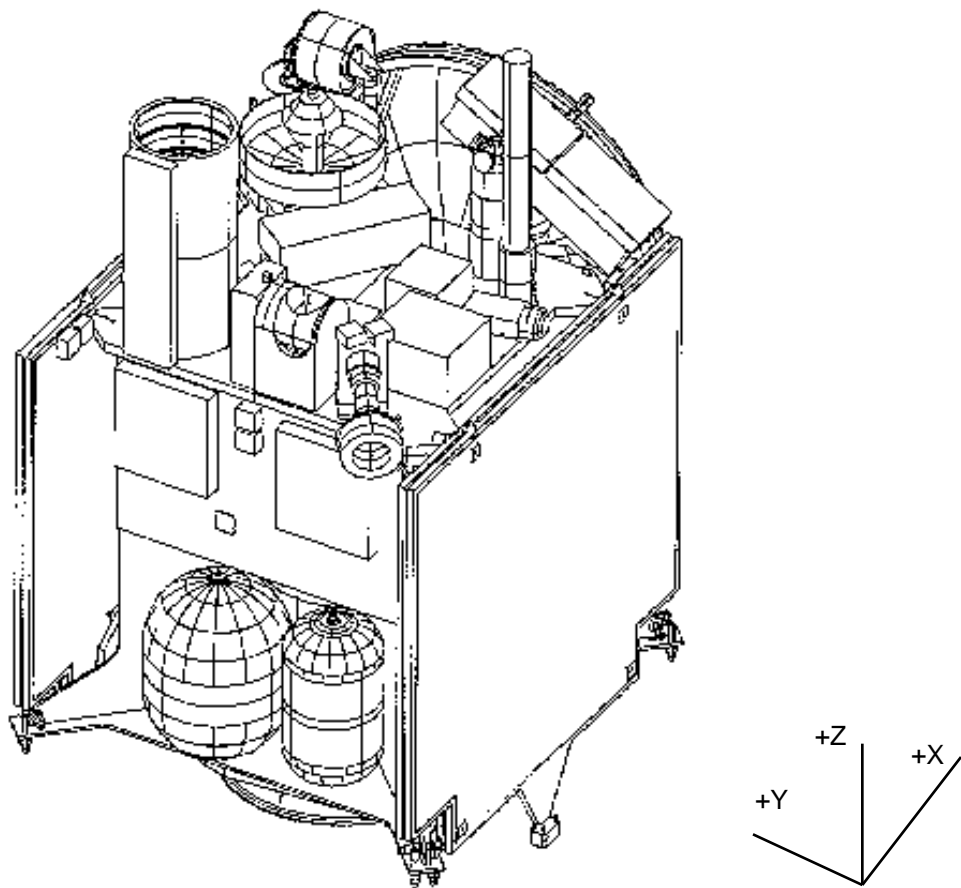


Figure 2.1 Spacecraft Coordinate System  
(MGS Spacecraft - Launch Configuration)

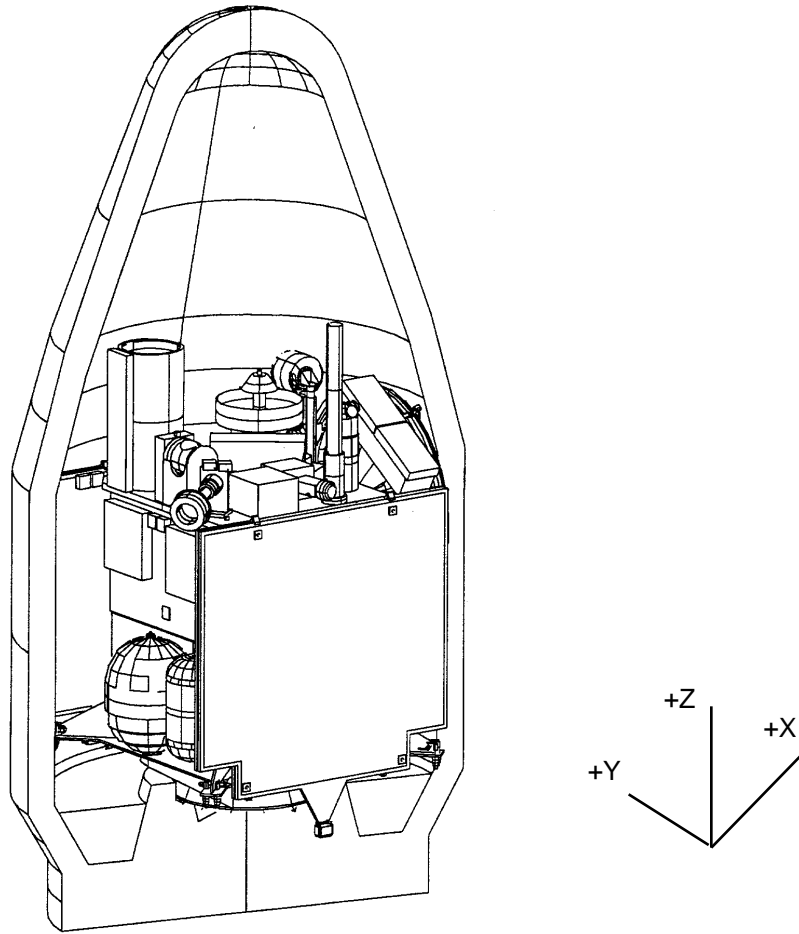


Figure 2.2 Spacecraft Coordinate System  
(MGS Spacecraft - Launch Configuration with Delta Payload Fairing)

## SECTION 3

### TARGETING AND ATTITUDE REQUIREMENTS

#### 3.1 LAUNCH PERIOD

The 21-day launch period begins on November 5, 1996 and extends through November 25, 1996. The launch period is composed of 32 instantaneous launch opportunities.

#### 3.2 LAUNCH WINDOWS / LAUNCH AZIMUTHS

The daily launch windows are of an instantaneous duration. Instantaneous is defined as  $\pm 1.0$  second. Determination of the daily launch window defines the liftoff time for a given launch opportunity.

A Delta II 7925A launch is planned only during the second daily launch opportunity, synonymous with a short coast parking orbit or an ascending node injection.

Three launch azimuths will be utilized during the MGS launch period. These launch azimuths will be selected according to the following launch strategy:

- (1) From November 5 through November 15, 1996, the Delta Program will plan to support two instantaneous daily launch windows. At the opening of the launch period, the separation time between the two instantaneous daily launch windows will be 64 minutes. This condition will be achieved by the judicious selection of two discrete launch azimuths.

Launch azimuth (first launch window) = 93.00 deg  
Launch azimuth (second launch window) = 99.89 deg

- (2) From November 16 through November 25, 1996, the Delta Program will plan to support one instantaneous daily launch window. The launch azimuth will be selected to be consistent with the required declination of the launch asymptote (DLA) for the November 25th launch date.

Launch azimuth = 110.00 deg

- (3) All launch azimuths will be selected on the basis of maximizing launch vehicle performance and meeting range safety requirements.

#### 3.3 LIFTOFF TIMES

Liftoff times will be specified to the nearest second. Liftoff times will be determined based on the target sets provided in Section 4.

#### 3.4 DELTA SECOND STAGE PROBABILITY OF COMMAND SHUTDOWN

The minimum acceptable Delta second stage probability of command shutdown (PCS) shall be 95.0%. Depending upon a given spacecraft injected mass and the desired target sets for a given launch day, the launch period specified in Section 3.1 may be modified.

### 3.5 DELTA THIRD STAGE BALLAST

The MGS spacecraft does not have the capability to ballast the Delta third stage.

### 3.6 INJECTION ENERGY / DECLINATION OF THE LAUNCH ASYMPTOTE

During the MGS launch period, the injection energy per unit mass ( $C_3$ ) decreases from a maximum of nearly  $10.4 \text{ km}^2/\text{s}^2$  to a minimum of approximately  $8.9 \text{ km}^2/\text{s}^2$  and then increases to nearly  $9.3 \text{ km}^2/\text{s}^2$ .

During the MGS launch period, the declination of the launch asymptote (DLA) increases from approximately 19.7 deg to 36.5 deg.

### 3.7 PARKING ORBIT INCLINATIONS

The parking orbit inclinations associated with the launch azimuths specified in Section 3.2 are tabulated in the following table:

Table 3.1 Parking Orbit Inclinations

Launch Azimuth (deg)	Parking Orbit Inclination (deg)
93.00	28.470
99.89	29.818
110.00	36.500

### 3.8 SPACECRAFT SEPARATION

The nominal separation of the MGS spacecraft from the Delta third stage occurs before the spacecraft reaches the targeting interface point (TIP). The spacecraft separation system is equipped with 4 spring actuators resulting in a spacecraft impulse at separation. This spacecraft separation impulse shall be included in the targeting process. (This separation system results in a nominal Delta third stage-to-spacecraft relative velocity of approximately 1.646 m/s (5.4 fps). This separation impulse nominally imparts 0.274 m/s (0.9 fps) posigrade into the spacecraft's trajectory and 1.372 m/s (4.5 fps) retrograde into the third stage's trajectory (Reference 4)).

### 3.9 SPACECRAFT INJECTED MASS

The spacecraft injected mass to be used for the Detailed Test Objectives (DTO) trajectory design cycle will be communicated by letter on or before February 29, 1996. The target sets specified in Table 4.1 (Section 4.1) were generated using an injected mass of 1055.0 kg.

### 3.10 SPACECRAFT MASS AND MASS PROPERTIES

Table 3.2 shows a set of mass properties considered to be consistent with the 1055.0 kg spacecraft injected mass. The spacecraft mass properties will be updated prior to the initiation of the MDA final separation and nutation control system (NCS) analyses.

The mass properties given in Table 3.2 are for the spacecraft in the launch configuration. The table contains entries for the following 3 cases:

- 1) 1G No Spin,
- 2) 1G Spin, and
- 3) 0G Spin.

Note that the MGS spacecraft principal axis misalignment with respect to the launch vehicle center line will always be less than 1.0 deg. This will be achieved by adding ballast to the MGS spacecraft.

The uncertainties in the spacecraft mass, the center of mass location, and the associated mass properties are expected to be less than 1.0% following the spin balance of the spacecraft at the Kennedy Space Center (KSC).

### 3.11 DELTA THIRD STAGE BURN SPIN RATE

The nominal combined Delta third stage/spacecraft spin rate during the Delta third stage burn shall be 60.0 rpm.

### 3.12 NUTATION TIME CONSTANT

The combined Delta third stage/spacecraft nutation time constants are the following:

At third stage ignition: 131.0 s (worst case)

At third stage burnout: 55.0 s (worst case)

These values are based in part on data from Reference 5. The values noted are consistent for the spacecraft mass properties given in Table 3.1 (Section 3.10) and the nominal Delta third stage burn spin rate of 60.0 rpm (Section 3.11).

### 3.13 TARGETING CONSTANTS

The gravitational constants to be used for trajectory modeling shall be consistent with the constants indicated in Appendix A.

### 3.14 TARGETING ERROR REQUIREMENT

Targeting errors due to tolerances in the targeting process shall be included as error sources when computing Delta third stage injection accuracy. The cost of removing these targeting errors shall not exceed 2.5 m/s when corrected with a trajectory correction maneuver at injection plus 15 days.

### 3.15 FREE MOLECULAR HEATING RATE

The theoretical free molecular heating rate on the spacecraft at the of time of payload fairing jettison shall not exceed 1135.0 W/m<sup>2</sup> (0.1 Btu/ft<sup>2</sup>-s) (Reference 6).

### 3.16 SUN ANGLE CONSTRAINTS

The spacecraft +Z-axis shall be maintained at an angle greater than 30.0 deg relative to the sun-spacecraft line. For those periods of time when the spacecraft +Z-axis must be less than 30.0 deg from the sun-spacecraft vector, a slew rate of greater than 0.4 deg/s shall be maintained.

Table 3.2 MGS Spacecraft Mass and Mass Properties

Spacecraft Configuration	Spacecraft Mass (kg)	Center of Mass (cm)*			Moments and Products of Inertias (kg-m <sup>2</sup> )					
		X	Y	Z	I <sub>xx</sub>	I <sub>yy</sub>	I <sub>zz</sub>	I <sub>xy</sub>	I <sub>yz</sub>	I <sub>xz</sub>
Launch - 1G No Spin	1055.0	-0.10	-0.07	113.20	561.4	619.4	380.0	-20.2	3.1	1.0
Launch - 1G Spin	1055.0	-0.10	-0.07	113.30	560.9	621.0	382.9	-21.2	3.1	1.0
Launch - 0G Spin	1055.0	-0.10	-0.07	114.10	558.3	618.6	383.4	-21.2	3.1	1.0

\*with respect to the separation plane oriented along the spacecraft coordinate system

Note that the MGS spacecraft principal axis misalignment with respect to the launch vehicle center line will always be less than 1.0 deg. This will be achieved by adding ballast to the MGS spacecraft.

### 3.17 THERMAL ROLL

During those periods of flight not constrained by launch vehicle requirements (e.g. launch vehicle coast periods), a thermal roll (preferred rate 3 deg/s) is required. During the thermal roll, the preferred spacecraft attitude places the spacecraft's +Z-axis perpendicular to the sun-spacecraft vector.

### 3.18 SPACECRAFT SEPARATION ATTITUDE

The spacecraft separation attitude is established by the required burn direction of the Delta third stage.

### 3.19 COLLISION AVOIDANCE

Delta third stage/spacecraft collision avoidance will be achieved by delaying the separation of the spacecraft from the third stage until chuffing of the third stage motor has been completed and by the establishment of a positive separation rate imparted by the four separation spring actuators associated with the spacecraft separation mechanism.

## SECTION 4

### TARGET CONDITIONS

#### 4.1 TARGET SETS

The target sets represent the conditions of the osculating departure hyperbola at the targeting interface point expressed in an Earth centered, inertial, Earth Mean Equator and Equinox of Epoch J2000 (EME2000) coordinate system. The epoch of the targeting interface point is defined to be 10 minutes after Delta third stage ignition.

The Earth relative target conditions are specified by expressing the injection energy per unit mass ( $C_3$ ), the declination of the departure or launch asymptote (DLA), and the right ascension of the departure or launch asymptote (RLA). These three parameters constitute a target set for a given launch date. Because the target sets are a function of time, a different target set is required for each launch date. Table 4.1 contains the target sets for the MGS launch period. These target sets (defined at the TIP) are expected to be consistent with the liftoff times necessary for a Delta II 7925A short coast injection.

#### 4.2 PLANETARY PROTECTION BIASING

All of the interplanetary transfer trajectories presented in Table 4.1 are targeted to biased aimpoints at Mars in order to satisfy the NASA Planetary Protection requirements (Reference 7). The requirements state that “The probability of impact by the launch vehicle (or any stage thereof) must not exceed  $10^{-4}$ .” This means that each interplanetary trajectory will require a trajectory correction maneuver (TCM) during cruise to remove the injection bias.

Table 4.1 MGS Target Sets  
(DLA and RLA referenced with respect to EME2000)

Launch Date	Launch Azimuth = 93.0 deg			Launch Azimuth = 99.89 deg		
	C3 (km <sup>2</sup> /s <sup>2</sup> )	DLA (deg)	RLA (deg)	C3 (km <sup>2</sup> /s <sup>2</sup> )	DLA (deg)	RLA (deg)
05-Nov-96	10.3826	20.8129	173.4556	10.3793	20.8287	173.5053
06-Nov-96	10.1656	21.2815	173.2868	10.1551	21.3062	173.2849
07-Nov-96	9.9846	21.8151	173.3121	9.9747	21.8430	173.3104
08-Nov-96	9.7984	22.4474	173.1808	9.7890	22.4782	173.1780
09-Nov-96	9.6412	23.0918	173.1528	9.6324	23.1246	173.1488
10-Nov-96	9.4837	23.8150	172.9559	9.4755	23.8502	172.9506
11-Nov-96	9.3549	24.5143	172.8633	9.3473	24.5515	172.8567
12-Nov-96	9.2314	25.2983	172.6072	9.2246	25.3382	172.5995
13-Nov-96	9.1257	26.1236	172.3150	9.1198	26.1667	172.3063
14-Nov-96	9.0466	26.8873	172.1402	9.0287	27.1824	171.7576
15-Nov-96	8.9811	27.7543	171.8299	8.9725	28.1834	171.3326

Launch Date	Launch Azimuth = 110.0 deg		
	C3 (km <sup>2</sup> /s <sup>2</sup> )	DLA (deg)	RLA (deg)
16-Nov-96	8.9162	28.7341	171.5825
17-Nov-96	8.8939	29.6635	171.2614
18-Nov-96	8.8888	30.4871	171.0732
19-Nov-96	8.9003	31.2739	170.9072
20-Nov-96	8.9336	32.2347	170.6113
21-Nov-96	8.9721	33.0381	170.4474
22-Nov-96	9.0213	33.8373	170.2947
23-Nov-96	9.1017	34.8534	170.0216
24-Nov-96	9.1758	35.6671	169.8820
25-Nov-96	9.2576	36.4706	169.7374

## SECTION 5

### TRAJECTORY DATA REQUIREMENTS

This section defines the minimum trajectory data products required by the MGS Project from the Delta Program. These data shall be supplied as a part of the MDA Detailed Test Objectives (DTO) Report for all launch opportunities selected for final targeting following the release of the Final MGS Delta II 7925A Target Specification. The expected delivery date of the DTO Report and the other launch trajectory data specified below is May 1, 1996.

#### 5.1 LAUNCH PROFILE DATA

Launch profile data describing the trajectory of the Delta II 7925A launch vehicle and the MGS spacecraft are required for all targeted injection opportunities.

For each launch day, the following events measured in seconds from liftoff time on the specified launch day are required to be defined:

- (1)
  - (a) Liftoff Time (measured in seconds from 0 hours UTC)
  - (b) Parking Orbit Insertion - First Cutoff Delta Stage II (SECO 1),
  - (c) Restart Delta Stage II
  - (d) Second Cutoff Delta Stage II (SECO 2),
  - (e) Delta Stage III Ignition
  - (g) Injection - Delta Stage III Burnout (TECO),
  - (h) Delta Stage III / Spacecraft Separation, and
  - (i) Targeting Interface Point (TIP).
- (2) State vectors at the events listed above expressed in cartesian coordinates relative to an Earth centered, inertial, Earth Mean Equator and Equinox of Epoch J2000 coordinate system.
  - (a) X-component of vehicle position (km)
  - (b) Y-component of vehicle position (km)
  - (c) Z-component of vehicle position (km)
  - (d) X-component of vehicle velocity (km/s)
  - (e) Y-component of vehicle velocity (km/s)
  - (f) Z-component of vehicle velocity (km/s)

The data will be provided in an MDA standard GVPAT output format (50 rows x 4 columns) and sent to JPL electronically (Reference 8).

## 5.2 TARGETING CERTIFICATION TRAJECTORIES

Trajectory certification is part of the targeting validation process that follows the release of the final version of this document. The following describes the requirements to complete this process.

Certification of the trajectories listed in Section 5.2.1 requires the data listed in Section 5.2.2 for the events listed in Section 5.2.3. The data shall be supplied in tabular form and electronically (if practical) for all trajectories explicitly simulated.

### 5.2.1 Trajectories

A trajectory shall be supplied for each launch opportunity selected for final targeting.

### 5.2.2 Trajectory Data

As a minimum, the following quantities are required for the trajectories specified in Section 5.2.1. The units and coordinate systems are also specified where applicable.

- (1) Launch date, UTC (day, month, year)
- (2) Liftoff time, UTC (measured in seconds from 0 hours UTC)

The following data are required for each event listed in Section 5.2.3:

- (3) Mission elapsed time (MET) from liftoff (seconds)
- (4) Vehicle weight (lb)
- (5) X-component of vehicle position (km, EME2000)
- (6) Y-component of vehicle position (km, EME2000)
- (7) Z-component of vehicle position (km, EME2000)
- (8) X-component of vehicle velocity (km/s, EME2000)
- (9) Y-component of vehicle velocity (km/s, EME2000)
- (10) Z-component of vehicle velocity (km/s, EME2000)
- (11) Launch vehicle centerline azimuth angle, PSILP (deg)
- (12) Launch vehicle centerline elevation angle, THETLP (deg)
- (13) Body axes orientation with respect to the MDA Earth-centered-inertial (I) frame.  
Array of 9 direction cosines., BI1, ...,BI9
- (14) Instantaneous launch vehicle geocentric latitude, RHOP (deg)
- (15) Instantaneous launch vehicle longitude from Greenwich, positive west, UMU (deg)
- (16) DSN station range (km)
- (17) DSN station azimuth (deg)     *The DSN station locations are given in Appendix A.*

- (18) DSN station elevation (deg)

The following departure asymptote quantities are required at injection (Delta Stage III Burnout (TECO)) and at the targeting interface point (TIP) (Section 5.2.3 items (5) and (7)):

- (19)  $C_3$  ( $\text{km}^2/\text{s}^2$ )
- (20) Declination of the launch (departure) asymptote (deg, EME2000)
- (21) Right ascension of the launch (departure) asymptote (deg, EME2000)

Items (11) through (15) will be used to verify compliance with the spacecraft sun angle constraint. Items (16) through (18) will be used to verify DSN acquisition predictions and support acquisition planning.

Items (1) through (20) are standard outputs of the GVPAT program. Delivery of the launch profile data (Section 5.1) in the standard GVPAT output with the appropriate parameters above included will satisfy the trajectory data requirements of this section.

### 5.2.3 Events

The events for the quantities specified in Section 5.2.2 are:

- (1) Parking Orbit Insertion - First Cutoff Delta Stage II (SECO 1)
- (2) Restart Delta Stage II
- (3) Second Cutoff Delta Stage II (SECO 2)
- (4) Delta Stage III Ignition
- (5) Injection - Delta Stage III Burnout (TECO)
- (6) Delta Stage III / Spacecraft Separation
- (7) Targeting Interface Point (TIP)

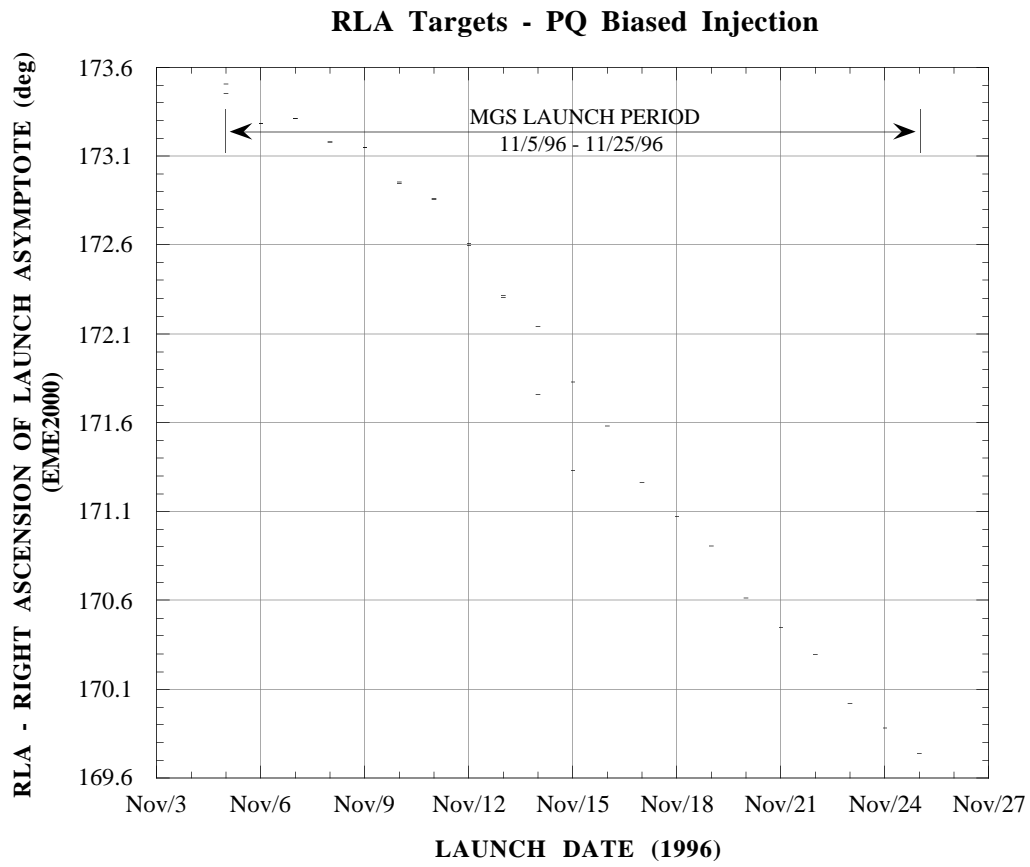


Figure B.3 RLA Targets

## **SECTION 6**

### **REFERENCES**

- [1] Pudil, R. W., "Preliminary Mission Analysis for the Mars Global Surveyor Spacecraft Mission - CDRL C3-03 - Contract NAS5-30722," McDonnell Douglas Memorandum A3-L230-M-96-XXX, XX January 1996. (Unsigned Preliminary Copy).
- [2] Johnston, M. D. and Spencer, D. A., "MGS/MPF Delta II 7925 Target Specification Discussion: Defining the Targeting Interface Point (TIP)," JPL Interoffice Memorandum MGS MOS 95-033, 15 March 1995.
- [3] "Mars Observer Planetary Constants and Models", JPL D-3444, (Project Document 642-321), November 1990.
- [4] McDonnell Douglas Aerospace, "Mars Global Surveyor (MGS) Preliminary Separation Analysis Report," To Be Issued.
- [5] Harrison, Jon V., "Final Report - Mars Global Surveyor Drop Test Program," Prepared for Lockheed Martin Astronautics Group, Technical Report Contract NO. RF5-438037, 11 May 1995.
- [6] Martin Marietta Technologies Inc., "Mars Global Surveyor (MGS) Spacecraft Performance and Interface Specification," Document No. MCR-94-4119, DRD No. SE 001, Contract Number: 960048, Revision Basic, April 1995.
- [7] Alwar, V. and Bollman, W. E., "Final Launch Aiming Points for Mars Global Surveyor," JPL Interoffice Memorandum 312.B-96-005, 1 February 1996.
- [8] Johnston, M. D., "MGS Launch Profile Data Telecon," JPL Interoffice Memorandum MGS MOS 95-156, 27 December 1995.

### **REFERENCED IN APPENDICES**

- [9] Marsh, J. G., et al, "The GEM-T2 Gravitational Model," NASA Technical Memorandum 100746, NASA Lewis Research Center and Maryland University, October, 1989.
- [10] "Deep Space Network / Flight Project Interface Design Handbook", JPL Document 810-5, Rev. D, Volume I, 1 April 1989.

## APPENDIX A

### CONSTANTS

#### A.1 TARGETING CONSTANTS

The following constants are taken from the GEM-T2 Earth gravity field model (Reference 9) and the JPL DE-403 planetary ephemeris. Although gravitational harmonics of up to order eight and degree eight were used from GEM-T2, the gravitational constants given below represent the dominant perturbative forces used in the targeting process.

GM of Earth	=	398600.436 km <sup>3</sup> /s <sup>2</sup>	(GEM-T2)
Earth Gravitational Equatorial Radius	=	6378.137 km	(GEM-T2)
2nd Zonal Harmonic Coefficient of Earth, J <sub>2</sub>	=	.1082626634949978D-02	(GEM-T2)
3rd Zonal Harmonic Coefficient of Earth, J <sub>3</sub>	=	-.2532094676466158D-05	(GEM-T2)
4th Zonal Harmonic Coefficient of Earth, J <sub>4</sub>	=	-.1619901210000001D-05	(GEM-T2)
GM of Moon	=	4902.800 km <sup>3</sup> /s <sup>2</sup>	(DE-403)

#### A.2 LAUNCH SITE LOCATION

The following coordinates define the location of Launch Complex 17 at the USAF Eastern Space and Missile Center at the Cape Canaveral Air Force Station in Florida.

Location	Radius (km)	Geodetic Latitude (deg)	Longitude (East) (deg)
Launch Complex 17	6373.346	28.446462	279.4347

#### A.3 DEEP SPACE NETWORK STATION LOCATIONS

The following coordinates define the 34-meter, high efficiency, deep space network (DSN) station locations. The geocentric station locations were taken from Reference 10.

DSN Station	Location	Geocentric Coordinates		
		Radius (km)	Latitude (deg)	Longitude (East) (deg)
DSS 15	Goldstone	6371.966	35.240	243.113
DSS 45	Canberra	6371.676	-35.217	148.978
DSS 65	Madrid	6370.022	40.237	355.749

## APPENDIX B

### TARGET SET FIGURES

Table 4.1 is the official “Mars Global Surveyor Target Table.” Figures B-1 through Figure B-3 show the various target parameters as a function of launch day and have been included here solely for informational purposes. The TIP times used in the determination of the target parameters below are expected to be consistent with the liftoff times necessary for a Delta II 7925A short coast injection.

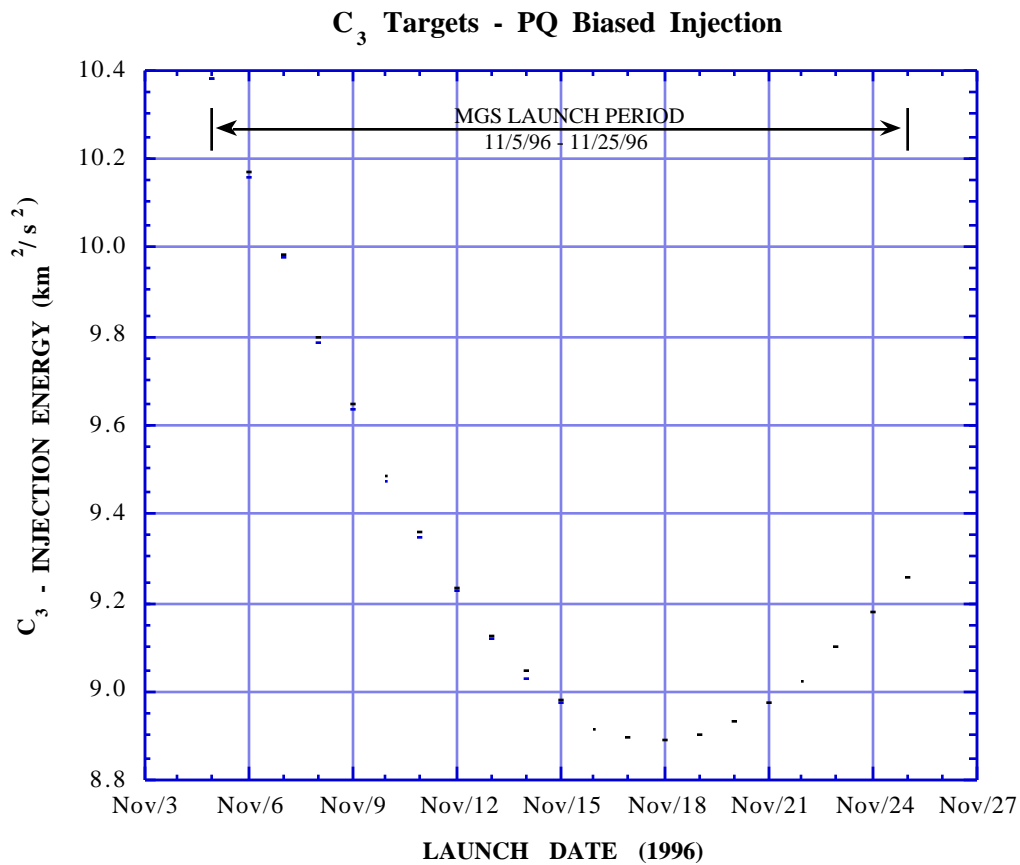


Figure B.1 C3 Targets

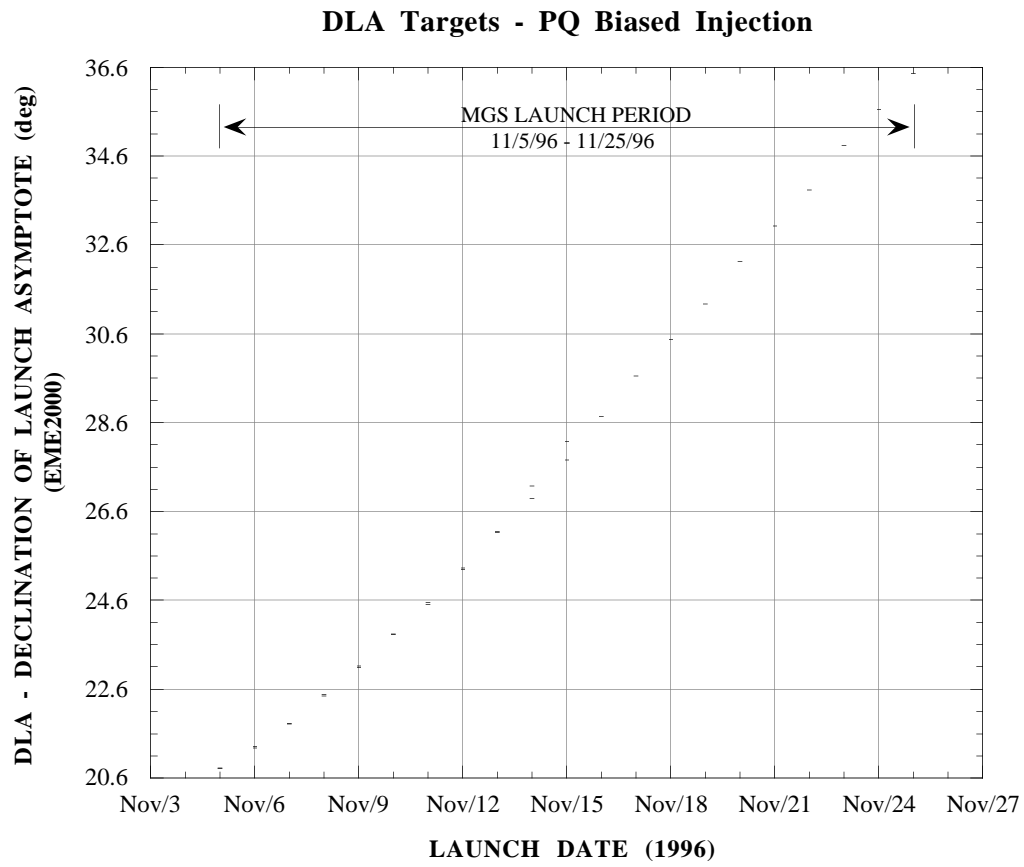


Figure B.2 DLA Targets

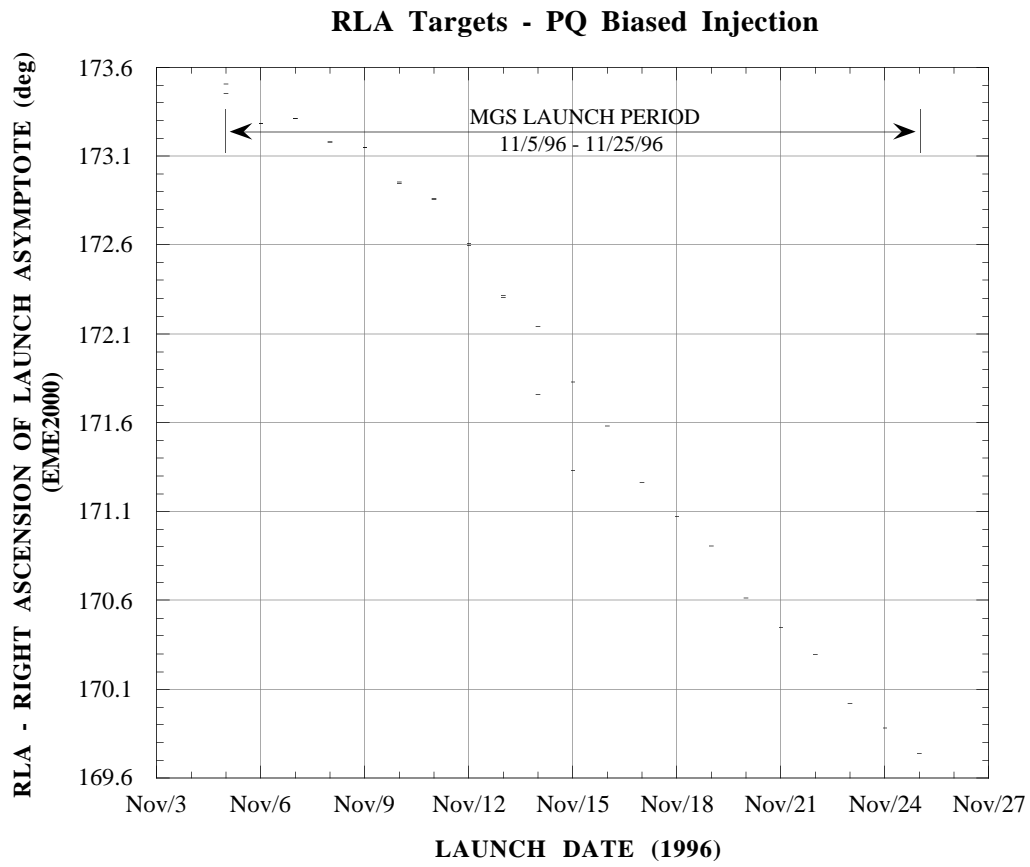


Figure B.3 RLA Targets